Chapter 20

Using the KAD/ADC/008

TEC/NOT/037

This technical note discusses the following topics:

20.1 Introducing the KAD/ADC/008

The KAD/ADC/008 is a monitor for 3-phase power lines. It allows many parameters associated with 3-phase power supplies to be easily measured and embedded in an Acra KAM-500 data output stream (PCM, Ethernet etc.). The AC parameters measured include: maximum, minimum, amplitude, average and root-mean-square (RMS) for both voltages and currents; active and apparent power, together with the power factor for each phase. In order to maximize the accuracy of these calculations, the KAD/ADC/008 converts all voltages and currents into the digital domain.

The physical interface of the KAD/ADC/008 comprises six single-ended input channels: three of these are for the three voltages of the 3-phase power supply. The other three channels are for measurement of the three currents of the 3-phase power supply.

NOTE: All six channels measure voltages. Therefore, a current transformer and resistor circuit is used to generate a voltage proportional to the current for the three current phase channels.

The KAD/ADC/008 simultaneously over-samples all six channels at 125 ksps. Various algorithms are performed to calculate each of the measurements. In fact, 40 different parameters associated with 3-phase power supplies are measured/calculated. A summary of these parameters is provided below with each of the parameters discussed in detail in Table 20.4 on page 5.

- Maximum (× 6 - for each channel Ch0 –> Ch5)
- Minimum (× 6 - for each channel Ch0 –> Ch5)
- Amplitude (× 6 - for each channel Ch0 –> Ch5)
- RMS (× 6 - for each channel Ch0 –> Ch5)
- Average (× 6 - for each channel Ch0 –> Ch5)
- Active power (× 3 - Phase 0 –> 2)
- Apparent power (× 3 - Phase 0 –> 2)
- Power factor (× 3 - Phase 0 –> 2)
- PERIOD (× 1 - Measured for 3-phase power supply)

In the calculations for any of the above parameters, the KAD/ADC/008 does not assume a sinusoidal shape but instead calculates these values based on all sample points. The KAD/ADC/008 assumes that the three phases are synchronous and assumes that the inputs are bipolar.

The algorithm used in the KAD/ADC/008 defines the start of each period as the time of the positive-going-zero-crossing of channel 0. The KAD/ADC/008 defines the end of each period as the time of the next positive-going-zero-crossing of channel 0. This crossing must be more than 50 ms after the first crossing. Over each period, each of the parameters listed above are calculated for the module. The processing algorithm is a hard-wired state machine with no microcode or forbidden states.

The KAD/ADC/008 has two analog gain ranges: ±1V and ±10V. The accuracy of the measurement of the KAD/ADC/008 when either range is chosen is ±0.25% of the full-scale range (FSR). Any FSR (up to a max. of ±10V) can be specified for the module. Digital gain is used on the module to map the analog range used (±10V or ±1V) to the chosen range. It should be noted that using digital gain decreases the accuracy of the card. For example, with a selected range of ±2V the module operates with an analog range of ±10V and a digital gain of 5. A digital gain of 5 means that the accuracy of the module may be increased to approximately 1%.

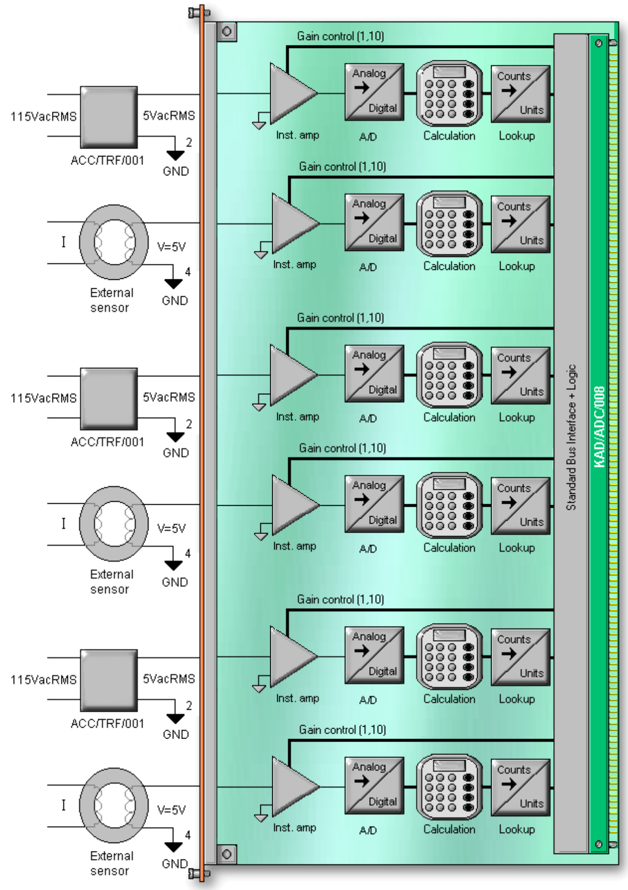


Figure 20-1: KAD/ADC/008 – 3-phase power monitor

20.2 Using transformers

When measuring or monitoring a power supply, it is desirable, if possible, to isolate the measurement from the power supply itself, so that the power supply does not get shorted or open-circuited during a fault condition. It is best to use a voltage-to-voltage transformer to measure each of the voltages of the 3-phase power supply, and to use a current-to-current transformer to measure each of the currents of the 3-phase power supply.

The ACC/TRF/002 from Curtiss-Wright is a six-channel voltage-to-voltage transformer for variable frequency supplies from 200 Hz to 900 Hz in a rugged housing, which is designed for use with the KAD/ADC/008. The ACC/TRF/002 has a primary-to-secondary-turns ratio of 20.9:1. This means that a 115V_{rms} input to the ACC/TRF/002 produces a 5.5V_{rms} output. This is fed directly to the voltage channel input of the KAD/ADC/008.

Similarly, the legacy ACC/TRF/001/B can be used with the KAD/ADC/008 and has a primary-to-secondary-turns ratio of 19.6:1 with a typical output of a 5.87 V_{rms}.

As previously noted, both the ACC/TRF/001/B and the ACC/TRF/002 can be used with the KAD/ADC/008, however the ACC/TRF/002 is recommended for new programs. Refer to the respective data sheet for more information.

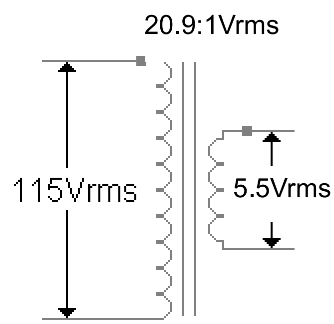


Figure 20-2: Voltage transformer for a single channel of the ACC/TRF/002

The $5.5V_{rms}$ input to the KAD/ADC/008 is approximately $14.14V_{p\text{-}p}$ or ±7.07V. The ADC voltage range for a voltage channel with $115V_{rms}$ input and using the ACC/TRF/002 should set the input voltage range to be greater than ±7.07V. It is advisable to leave some headroom so that clamping does not affect readings. A range of ±10V is typically used.

It is recommended to use a current transformer to measure the current of each phase. Curtiss-Wright does not manufacture current transformers for use with the KAD/ADC/008. One significant reason for this is because the rated temperature and current may vary greatly from application to application. Rated current is one of the key specifications for any current transformer. Other important requirements for the current transducer are accuracy specifications, temperature specifications, and size.

Curtiss-Wright suggests choosing a current transformer that meets the specifications required for a particular application. The CR Magnetics 8400 family of transformers may provide a suitable solution. The CR 8459 is a transformer which can measure large current loads. It's rated current is $200A_{rms}$. The CR 8459 can be used to measure current accurate to 0.2%. However, the CR 8459 is only specified over the temperature range -25°C to 66°C. If a -40°C to 85°C temperature range is required CR Magnetics also provide custom military specification current transformers. CR Magnetics can be contacted directly via their web site (www.crmagnetics.com).

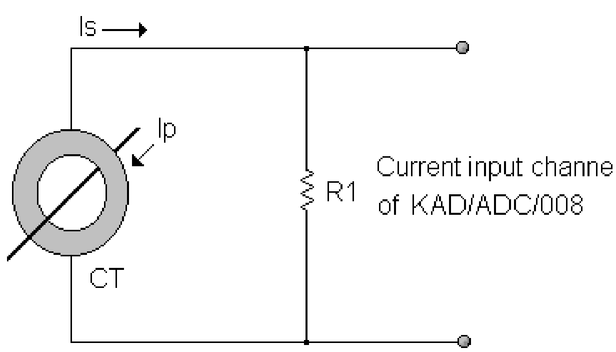


Figure 20-3: Current transformer external connection to the KAD/ADC/008

With current transformers the primary current carrying wire is fed through a current transformer. The induced secondary current is proportional to the primary current. Their relationship is given by:

$$I_S = \frac{I_P}{N}$$

where:

- I_S is the induced secondary current
- I_P is the primary current
- N is the turns ratio (secondary turns / primary turns)

The voltage input to the KAD/ADC/008 is:

$$V_I = I_S \times R_1$$

where:

- V_I is the induced voltage dropped over the burden resistor R_1

In current transformer applications, it is necessary to place a burden resistor across the output of the transformer. From a design standpoint, the primary function is to limit the output voltage so that the transformer is not allowed to saturate. From a circuit design point of view, the burden resistor is used to adjust the output of the transformer to the desired output for the particular circuit. In reality, both these criteria must be dealt with.

Instead of designing current transformers to operate with a given burden resistor value we suggest the following approach:

1. Select a current transformer that has the mechanical specifications required and meets maximum current, temperature, and accuracy specifications.
2. Specify the maximum voltage that can be measured by the acquisition circuit.
3. Specify or calculate the saturation voltage of the transformer at the desired frequency.
4. Calculate the maximum current in the secondary circuit of the transformer.
5. Using the minimum of the acquisition voltage (from 2) and saturation voltage (from 3) and the maximum secondary current (from 4) calculate the burden resistor.
6. Calculate the power dissipated by the burden resistor.

For many current transformers, it is best to keep voltage dropped over the resistor relatively small (circa 1V is fine from most current transformers). For this, the best accuracy may be obtained from the KAD/ADC/008 if the current channel is configured on the ±1V range as this uses a digital gain of 1, hence the accuracy of the module will be 0.25%. Generally, it is best to choose a resistor so that the peak voltage induced is less than 1V – say 900 mV.

From the equations above R_1 can be calculated as follows:

$$R_I = \frac{N \times V_I}{I_P}$$

If the ±1V range on the KAD/ADC/008 is chosen, it is important to choose R_1 so that the peak primary current induces a voltage less than ±1V.

$$R_I < \frac{N}{I_{p-p}}$$

where $I_{p\text{-}p}$ is the peak primary current.

It is also important that the resistor is chosen with a power rating in excess of the power absorbed by the resistor. The average power absorbed by the resistor is:

$$P_{R1} = \frac{I^2_{P-RMS}}{N^2} R_1$$

It should be noted that for large currents (~100A) and/or small turns ratio (~50) the power consumed by the resistor can be quite large. For example an RMS current of 100A passed once though a current transformer with a turns ratio of 50 would cause a 5Ω resistor connected across the secondary coil to be heated by 20W. This is a large power rating for a resistor and would melt standard resistors.

20.3 Example

What are the specifications of a resistor required to monitor the following 3-phase power supply?

- the maximum RMS primary current is $100A_{rms}$.
- the required temperature range is –10°C to 50°C
- an overall accuracy of better than 1% is required

Curtiss-Wright suggests using a CR 8459 current transformer from CR Magnetics. Verify that this is a suitable choice and choose a resistor to give optimal accuracy.

20.3.1 Check that the transformer meets the peak current of the supply

The rated current for the CR 8459 is $200A_{rms}$. This is greater than the required 100A maximum rms current. Hence the CR 8459 is suitable from this point of view. The accuracy of the CR 8459 is 0.2% (for loads > 40A).

20.3.2 Choose a resistor for optimal accuracy

The CR 8459 has 2000 secondary turns. Assuming that the primary wire is passed straight through the core, then the turns ratio is 2000:1. Assuming the primary current is approximately sinusoidal then the peak primary current is:

$$I_{P-PK} = \sqrt{2} \times I_{rms-MAX} = 141.1A$$

Hence the resistor *R* should be chosen so that

$$R_1 = \frac{N \times V_I}{I_P}$$

Choose R_1 so that the peak primary current $I_{\text{p-p}}$ induces a voltage within the ±1V range of the KAD/ADC/008.

$$R_1 < \frac{N}{I_{p-p}} < \frac{2000}{141.4} < 14.14\Omega$$

Assuming a 10Ω resistor, the power consumed by the resistor is given by:

$$P_{R1} = \frac{I^2_{P-rms}}{N^2} R_1 = \frac{100^2}{2000^2} 10 = 25mW$$

Hence choose a resistor that is rated to handle at least 25 mW of power. Any standard resistor will probably suffice.

20.3.3 Accuracy

Use a 10Ω burden resistor with the CR 8459 current transformer.

The KAD/ADC/008 is configured on the ±1V range. The primary current is $100A_{\text{rms}}$ or $\pm 141.4A_{p\text{-}p}$. Using a 10Ω burden resistor and 2000:1 turns ratio this results in ±141.4 × 10 / 2000 = ±0.707 volts generated across the burden resistor. Hence 70% of the FSR of the KAD/ADC/008 is used so the accuracy should be approximately 0.36%.

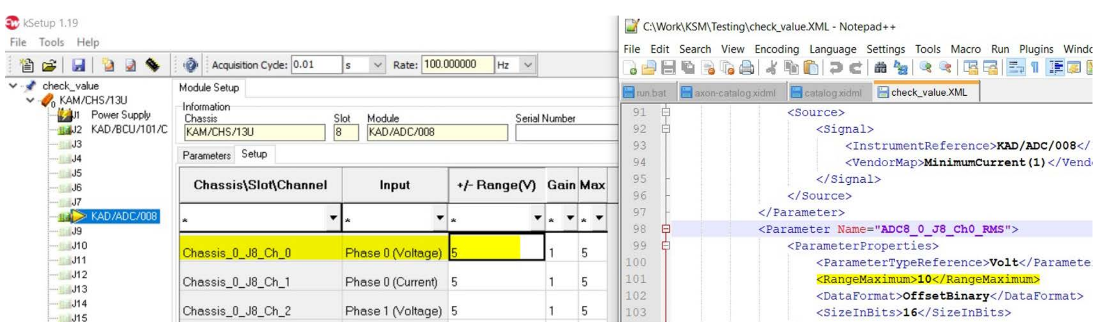
In the above example, the accuracy of the CR 8459 current transformer is approximately 0.2%.

Adding the two errors yields an overall accuracy of the sensor and acquisition to be better than 0.6% which is better than the overall requirement of 1%.

20.4 Output registers

The KAD/ADC/008 simultaneously measures/calculates 40 different parameters associated with 3-phase power supplies. A detailed description of each of these parameters is provided in the following table.

WARNING: In KSM-500 GUI, the VRANGE value that you enter is doubled when you save and open the XidML2.4 task file. As shown in this example, if VRANGE = 5 in KSM-500, then in the task file it shows as RangeMaximum=10.



Therefore if the range from the XidML2.4 task file is to be used for processing data, you must adjust the equation for the range in your processing software accordingly.

Table 20-1: Output registers

REGISTER	Notation (default name in KSM-500)	Description
CALCULATED PARAMETERS FOR ALL CHANNELS		
Maximum	ADC8_X_JY_Ch0_MAX ADC8_X_JY_Ch1_MAX ADC8_X_JY_Ch2_MAX ADC8_X_JY_Ch3_MAX ADC8_X_JY_Ch4_MAX ADC8_X_JY_Ch5_MAX	The maximum value of the analog input is measured for each of the six channels. This value is displayed in six different registers as shown in the notation column. The maximum value is always measured over the sample period as calculated by the KAD/ADC/008 and displayed in the PERIOD register. The input voltage range (V_{RANGE}) can be set by the user. MAX is calculated with 12 bits of resolution and is represented in OFFSET BINARY notation by the bits R[15:4]. Bits R[3:0] are reserved for future use. R[15:4] = $\left(\frac{V_{MAX} + V_{RANGE}}{2 \times V_{RANGE}}\right) \times 4096$ Example: Setting V_{RANGE} = 5 in KSM-500 (±5V analog range) then an $8V_{p\text{-}p}$ input with +0.5V of offset has a maximum at 4.5V. This maximum is represented by code 9.5 / 10 × *4096 = 3891. When read as a 16-bit register this will be represented as 62256.
Minimum	ADC8_X_JY_Ch0_MIN ADC8_X_JY_Ch1_MIN ADC8_X_JY_Ch2_MIN ADC8_X_JY_Ch3_MIN ADC8_X_JY_Ch4_MIN ADC8_X_JY_Ch5_MIN	The minimum value of the analog input is measured for each of the six channels. This value is displayed in six different registers as shown in the notation column. The minimum value is always measured over the sample period as calculated by the KAD/ADC/008 and displayed in the PERIOD register. The input voltage range (V_{RANGE}) is user-definable. MIN is calculated with 12 bits of resolution and is represented in OFFSET BINARY notation by the bits R[15:4]. R[3:0] are reserved for future use. R[15:4] = $\left(\frac{V_{MIN} + V_{RANGE}}{2 \times V_{RANGE}}\right) \times 4096$ Example: Setting V_{RANGE} = 5 in KSM-500 (±5V analog range) then an $8V_{p\text{-}p}$ input with +0.5V of offset has a minimum at -3.5V. This minimum is represented by code 1.5 / 10 × 4096 = 614. When read as a 16-bit register this will be represented as 9824.
Average	ADC8_X_JY_Ch0_AVG ADC8_X_JY_Ch1_AVG ADC8_X_JY_Ch2_AVG ADC8_X_JY_Ch3_AVG ADC8_X_JY_Ch4_AVG ADC8_X_JY_Ch5_AVG	The average value of the analog input is measured for each of the six channels. This value is displayed in six different registers as shown in the notation column. The average value is always measured over the sample period as calculated by the KAD/ADC/008 and displayed in the PERIOD register. The input voltage range (V_{RANGE}) can be set by the user. AVG is calculated with 16 bits of resolution and is represented in OFFSET BINARY notation by the bits R[15:0]. R[15:4] = $\left(\frac{V_{AVG} + V_{RANGE}}{2 \times V_{RANGE}}\right) \times 65536$ Example: Setting V_{RANGE} = 5 in KSM-500 (±5V analog range) then a $8V_{p\text{-}p}$ input with +0.5V of offset has an average of +0.5V. This average is represented by code 5.5 / 10 × 65536 = 36045.

Table 20-1: Output registers

REGISTER	Notation (default name in KSM-500)	Description
Amplitude	ADC8_X_JY_Ch0_AMP ADC8_X_JY_Ch1_AMP ADC8_X_JY_Ch2_AMP ADC8_X_JY_Ch3_AMP ADC8_X_JY_Ch4_AMP ADC8_X_JY_Ch5_AMP	The amplitude of the analog input is measured for each of the six channels. This value is displayed in six different registers as shown in the notation column. The amplitude value is always measured over the sample period as calculated by the KAD/ADC/008 and displayed in the PERIOD register. The input voltage range (V_{RANGE}) can be set by the user. *AMP* is calculated with 12 bits of resolution and is represented in OFFSET BINARY notation by the bits R[15:4]. R[3:0] are reserved for future use. R[15:4] = $\left(\frac{V_{MAX} - V_{MIN}}{2 \times V_{RANGE}}\right) \times 4096$ Example: Setting V_{RANGE} = 5 in KSM-500 (±5V analog range) then a $8V_{p\text{-}p}$ input with +0.5V of offset has an amplitude of +8V. This amplitude is represented by code 8/10 × 4096 = 3277. When read as a 16-bit register this will be represented as 52432.
RMS	ADC8_X_JY_Ch0_RMS ADC8_X_JY_Ch1_RMS ADC8_X_JY_Ch2_RMS ADC8_X_JY_Ch3_RMS ADC8_X_JY_Ch4_RMS ADC8_X_JY_Ch5_RMS	The RMS of the analog input is measured for each of the six channels. This value is displayed in six different registers as shown in the notation column. The RMS value is always measured over the sample period as calculated by the KAD/ADC/008 and displayed in the PERIOD register. The input voltage range (V_{RANGE}) is user-definable. Root-mean-square is calculated with 16 bits of resolution and is represented in OFFSET BINARY notation by the bits R[15:0]. V_{rms} = SQRT ((DC_rms)^2 + (AC_rms)^2) R[15:0] = $\left(\frac{V_{RMS}}{V_{RANGE}}\right) \times 65536$ Example: Setting V_{RANGE} = 5 in KSM-500 (±5V analog range) then a $8V_{p\text{-}p}$ input with +0.5V of offset has a V_{rms} as follows: V_{pp} = 8V DC_rms = 0.5 AC_rms = V_p / SQRT(2) = V_{pp} / (2 × SQRT(2)) = 8/ (2 × SQRT(2)) = 2.8284 V_{rms} = SQRT (0.5^2 + (2.8284)^2) = SQRT (0.25 + 8) = SQRT (8.25) $\frac{\sqrt{8.25}}{5} \times 65536 = 37648$

Table 20-1: Output registers

REGISTER	Notation (default name in KSM-500)	Description
Calculated parameters for pairs of channels		
Active power	ADC8_X_JY_Ph0_ACTPW ADC8_X_JY_Ph1_ACTPW ADC8_X_JY_Ph2_ACTPW	The active power is calculated for each pair of inputs (Ch0 and Ch1; Ch2 and Ch3; Ch4 and Ch5). In the calculation of the active power: Ch0, Ch2 and Ch4 should represent the voltage inputs; and Ch1, Ch3 and Ch5 should represent the current inputs for each of the three phases Ph0, Ph1 and Ph2. This active power is displayed in three different registers as shown in the notation column. The active power is always measured over the sample period as calculated by the KAD/ADC/008 and displayed in the PERIOD register. The input voltage range for each of the voltage and current channels can be set by the user. Let $V_{RANGE-V}$ be the range of the voltage input (Ch0, Ch2 or Ch4) and $V_{RANGE-I}$ be the range of the current input (Ch1, Ch3 or Ch5). ACTIVE power is calculated with 16 bits of resolution and is represented in OFFSET BINARY notation by the bits R[15:0]. $$P_{ACTIVE} = \frac{1}{N}\sum_{i=1}^{N} v_i \times i_i$$ R[15:0] = $\left(\frac{P_{ACTIVE} + (V_{RANGE-V} \times V_{RANGE-I})}{2 \times (V_{RANGE-V} \times V_{RANGE-I})}\right) \times 65536$ Example: Assume Ch0 has $V_{RANGE-V}$ = 5V and an 8V_{p-p} input with +0.5V of offset is connected. Assume Ch1 has $V_{RANGE-I}$ = 5V and an 8V_{p-p} input with +0.5V of offset is connected. Both channels have a frequency of 400 Hz and Ch1 is delayed by 10°. The Active power should be approximately 8.13W. This amplitude is represented by code (8.13 + 25) / 50 × 65536 = 43424
Apparent power	ADC8_X_JY_Ph0_APPPW ADC8_X_JY_Ph1_APPPW ADC8_X_JY_Ph2_APPPW	The apparent power is calculated for each pair of inputs (Ch0 and Ch1; Ch2 and Ch3; Ch4 and Ch5). In the calculation of the apparent power Ch0, Ch2 and Ch4 should represent the voltage inputs and Ch1, Ch3 and Ch5 should represent the current inputs for each of the three phases Ph0, Ph1 and Ph2. This apparent power is displayed in three different registers as shown in the notation column. The active power is always measured over the sample period as calculated by the KAD/ADC/008 and displayed in the PERIOD register. The input voltage range for each of the voltage and current channels is user-definable. Let $V_{RANGE-V}$ be the range of the voltage input (Ch0, Ch2 or Ch4) and $V_{RANGE-I}$ be the range of the current input (Ch1, Ch3 or Ch5). Apparent power is calculated with 16 bits of resolution and is represented in OFFSET BINARY notation by the bits *R*[15:0]. $$P_{APP} = V_{RMS} \times I_{RMS}$$ R[15:0] = $\left(\frac{P_{APP}}{V_{RANGE-V} \times V_{RANGE-I}}\right) \times 65536$ Example: Assume Ch0 has $V_{RANGE-V}$ = 5V and an 8V_{p-p} input with +0.5V of offset is connected. Assume Ch1 has $V_{RANGE-I}$ = 5V and an 8V_{p-p} input with +0.5V of offset is connected. Both channels have a frequency of 400 Hz and Ch1 is delayed by 10°. The Active power should be approximately 8.25W. This amplitude is represented by code 8.25 / 25 × 65536 = 21627

Table 20-1: Output registers

REGISTER	Notation (default name in KSM-500)	Description
Power factor	ADC8_X_JY_Ph0_PF ADC8_X_JY_Ph1_PF ADC8_X_JY_Ph2_PF	The power factor is calculated for each pair of inputs (Ch0 and Ch1; Ch2 and Ch3; Ch4 and Ch5). In the calculation of the power factor Ch0, Ch2, and Ch4 should represent the voltage inputs and Ch1, Ch3, and Ch5 should represent the current inputs for each of the three phases Ph0, Ph1, and Ph2. This apparent power is displayed in three different registers as shown in the notation column. The active power is always measured over the sample period as calculated by the KAD/ADC/008 and displayed in the PERIOD register. The power factor is calculated with 16 bits of resolution and is represented in OFFSET BINARY notation by the bits *R*[15:0]. Power factor will be in the range -1 to +1. $PF = \frac{P_{ACT}}{P_{APP}}$ R[15:0] = $\left(\frac{PF+1}{2}\right) \times 65536$ Example: Assume Ch0 has $V_{RANGE\text{-}V}$ = 5V and an 8$V_{p\text{-}p}$ input with +0.5V of offset is connected. Assume Ch1 has $V_{RANGE\text{-}I}$ = 5V and an 8$V_{p\text{-}p}$ input with +0.5V of offset is connected. Both channels have a frequency of 400 Hz and Ch1 is delayed by 10°. The Active Power should be approximately 8.13W.The Apparent Power should be approximately 8.25W. The power factor should be (8.13 / 8.25) = 0.985. This amplitude is represented by code (0.985+1) / 2 × 65536 = 65044
Calculated for channel 0 only		
PERIOD	ADC8_X_JY_PERIOD	The PERIOD is calculated for Ch0 only. The PERIOD is defined as the average time between positive going zero crossings for Ch0 and this channel. PERIOD is calculated with 16 bits of resolution and is represented in OFFSET BINARY notation by the bits *R*[15:0]. PERIOD is calculated with respect to 100 ms. R[15:0] = $\left(\frac{T_{PERIOD}}{0.1}\right) \times 65536$ Example: For a 400 Hz input at Ch0 the PERIOD will be 2.5 ms. This will be represented by 2.5e-3 / 0.1 × 65536 = 1638

20.5 Calculating the parameter from the measured count

Each of the 40 different parameters measured/calculated by the KAD/ADC/008 is represented as a 16-bit count. To convert a count into a voltage, current, power, or period the appropriate equation as shown below should be used. It is up to the user to calculate the primary voltages and currents based on the transformer used in their application.

Maximum voltage

$$V_{max} = \frac{R[15:0] \text{ x } V_{range}}{32768} - V_{range}$$

Minimum voltage

$$V_{min} = \frac{R[15:0] \text{ x } V_{range}}{32768} - V_{range}$$

Average voltage

$$V_{avg} = \frac{R[15:0] \text{ x } V_{range}}{32768} - V_{range}$$

Voltage amplitude ($V_{p\text{-}p}$)

$$V_{amp} = V_{max} - V_{min} = \frac{R[15:0] \text{ x } V_{range}}{32768}$$

RMS voltage

$$V_{rms} = \frac{R[15:0] \text{ x } V_{range}}{65536}$$

Active power (no assumption is made that the wave is sinusoidal)

$$P_{active} = \frac{R[15:0] \text{ x } V_{range\text{-}v} \text{ x } V_{range\text{-}I}}{32768} - (V_{range\text{-}v} \text{ x } V_{range\text{-}I})$$

Apparent power

$$P_{app} = \frac{R[15:0] \text{ x } V_{range\text{-}v} \text{ x } V_{range\text{-}I}}{65535}$$

Power factor

$$PF = \frac{R[15:0]}{32768} - 1$$

PERIOD

$$T_{period} = \frac{R[15:0] \text{ x } 100ms}{65536}$$

In each of the formulae *R*[15:0] is the register being read from the module in 16-bit mode.

Example: to calculate V_{MAX} use the ADC8_X_JY_ChZ_MAX register where *R*[15:0] appears in the formula.

Example: to calculate T_{PERIOD} use the ADC8_X_JY_PERIOD register where *R*[15:0] appears in the formula.

At least 2048 A/D readings are taken for each channel. If a DC signal is attached to a channel, the algorithm updates every 65,536 samples.

The ACC/TRF/002 is an external transformer that can be used to isolate and attenuate three voltages.

When programming the KAD/ADC/008, the relationship between the input voltage levels and the voltage and current being measured (scaling) should be specified.

20.6 Conclusion

In this paper, some of the nomenclature associated with power monitoring was introduced along with some formulae for deriving parameters such as maximum, minimum, amplitude, average, RMS, active power, apparent power and power factor.